Reduced NOx Emissions with Liquid Fuels

Presentation at Integrated Energy Systems Peer Review Meeting

April 30, 2002

Dr. Thomas A. Butcher

Brookhaven National Laboratory

Clean Oil Program in DER

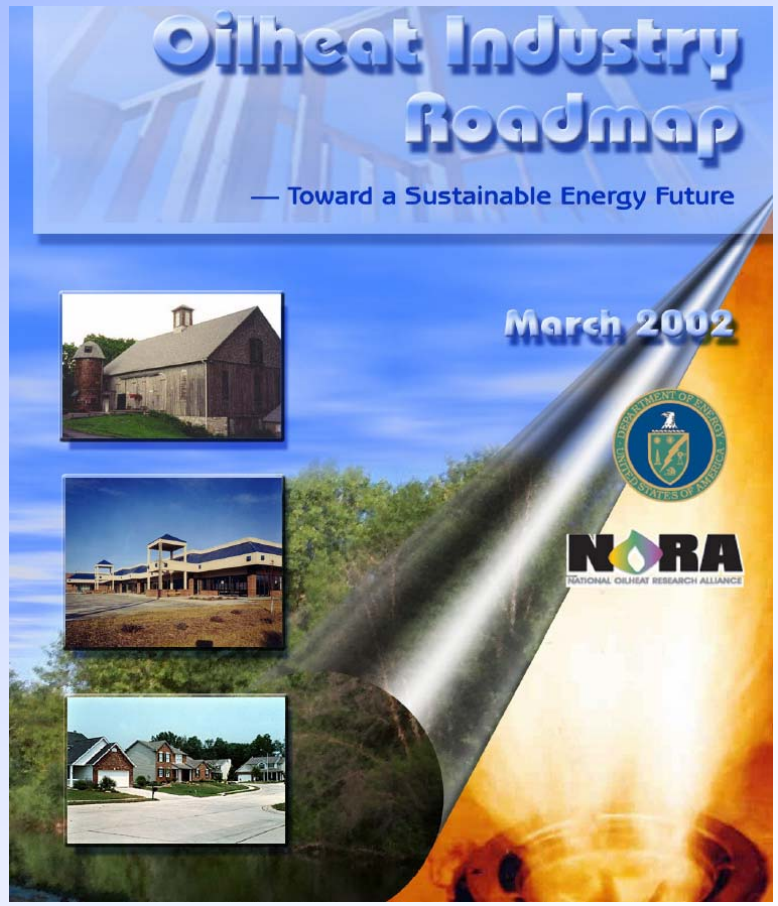
"Distributed Energy Resources offers a future where consumer choice drives market price, as well as, technology development. One key element of this will be fuel flexibility."

Fuel oil is an important component of America's energy diversity and security. Portability of fuel oil makes it the only choice for some applications.

Roadmap

Market sectors benefiting from this work include homes, manufacturing, commercial buildings, government facilities, hospital complexes, college campuses, public housing, municipalities, and power parks

Scope of interest includes boilers, furnaces, direct-fired absorption chillers, microturbines, IC engines, and fuel cells.



Fit with IES Mission

- Provides energy choice
- Reduces emissions
- Conserves fuel
- Increases energy security
- Optimizes energy delivery

Reduced NOx with Liquid Fuels

Main Objective - '01 / '02 work

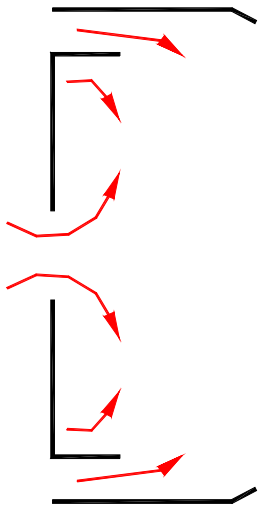
Provide technical foundation needed to achieve the goals set in the Roadmap - 70 ppm NOx near term, 20 ppm NOx long term in boilers.

Secondary Objectives

Lower firing rates

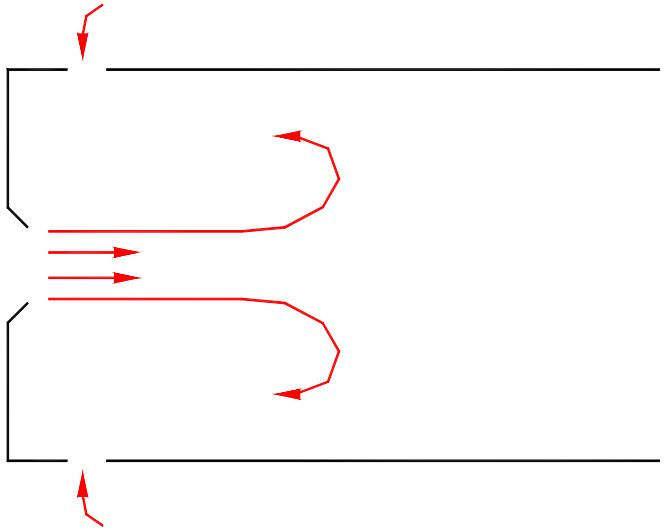
Preliminary experience with oil-fired direct absorption chillers and microturbines.

Conventional

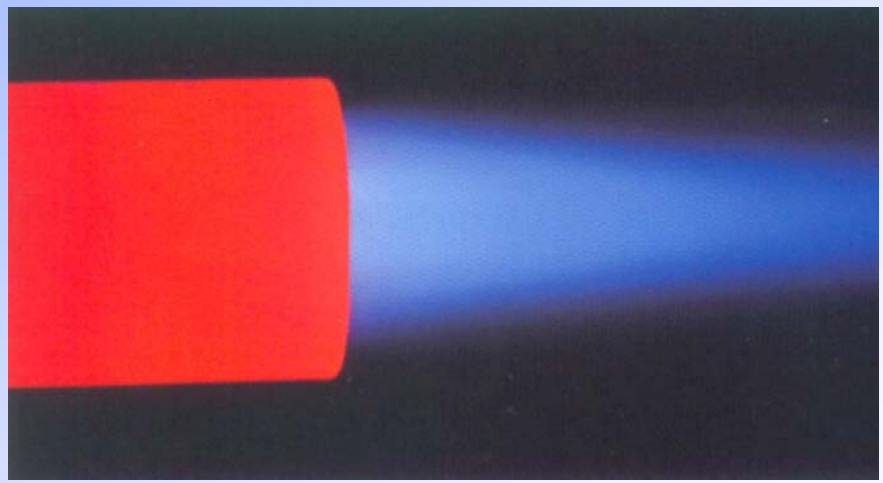


YELLOW FLAME RETENTION HEAD

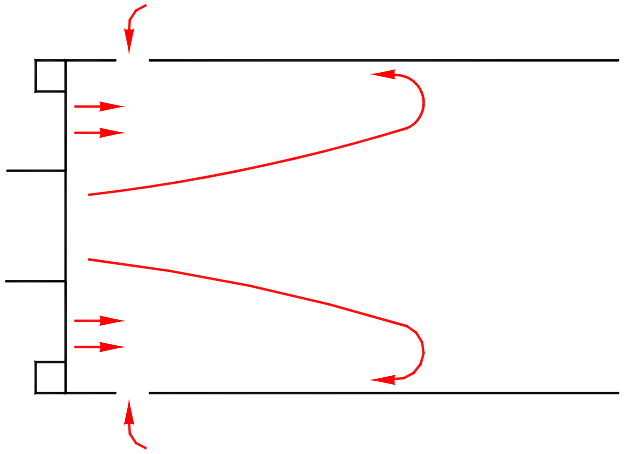
Moderate NOx



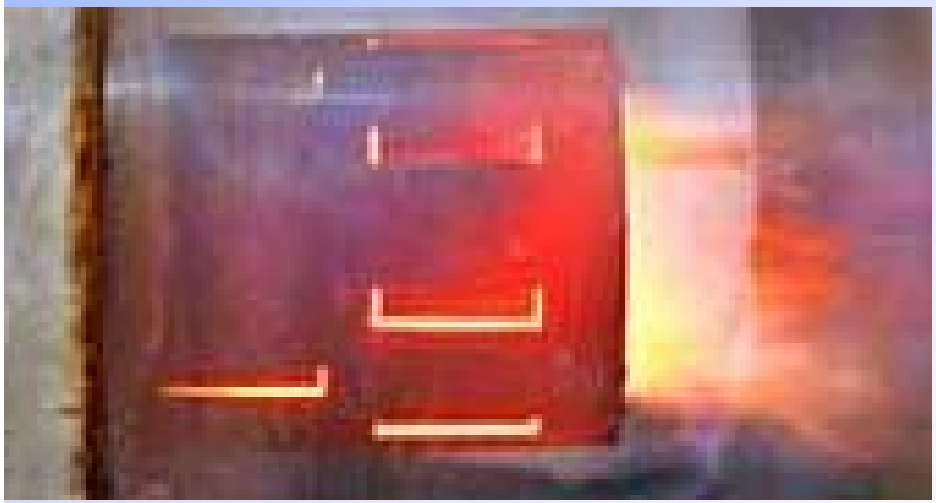
BLUE FLAME RECIRCULATING



Low Pressure Air Atomized



LP AIR ATOMIZED



Issues in Burner Design

- Ignition
- Flame stability during warm-up
- Amount of recirculation
- Coke on surfaces
- Flame color / sensing
- Transient emissions
- Cost / service requirements

BNL Work in FY '01 and ' 02

Objective - understanding flow patterns in burners and potential routes to lower NOx.

Tasks '01

Combustion tests with moderate NOx, blue flame burner.

Studies of impact of nozzle internal geometry on spray and flow patterns and combustion with air atomized nozzle.

BNL Work in FY '01 and '02

Tasks '02

LDV profiling of selected heads to obtain data on cold air velocity fields.

Efforts to approach 20 ppm target.

Oil-fired microturbine performance tests

Oil-fired absorption chiller tests

Tools for Studies of Burner Heads

Laser Fraunhofer diffraction system for spray droplet size distribution

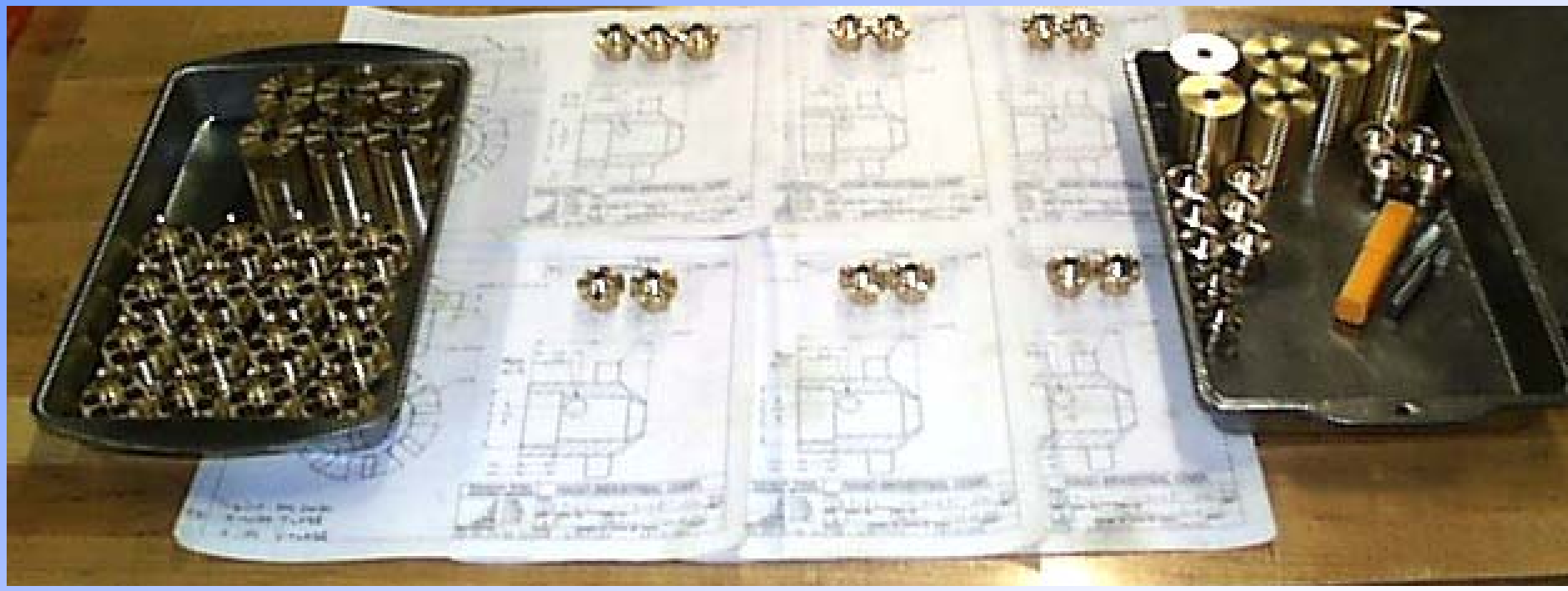
Collection system for spray patterns / angles

LDV for cold air velocity field measurements

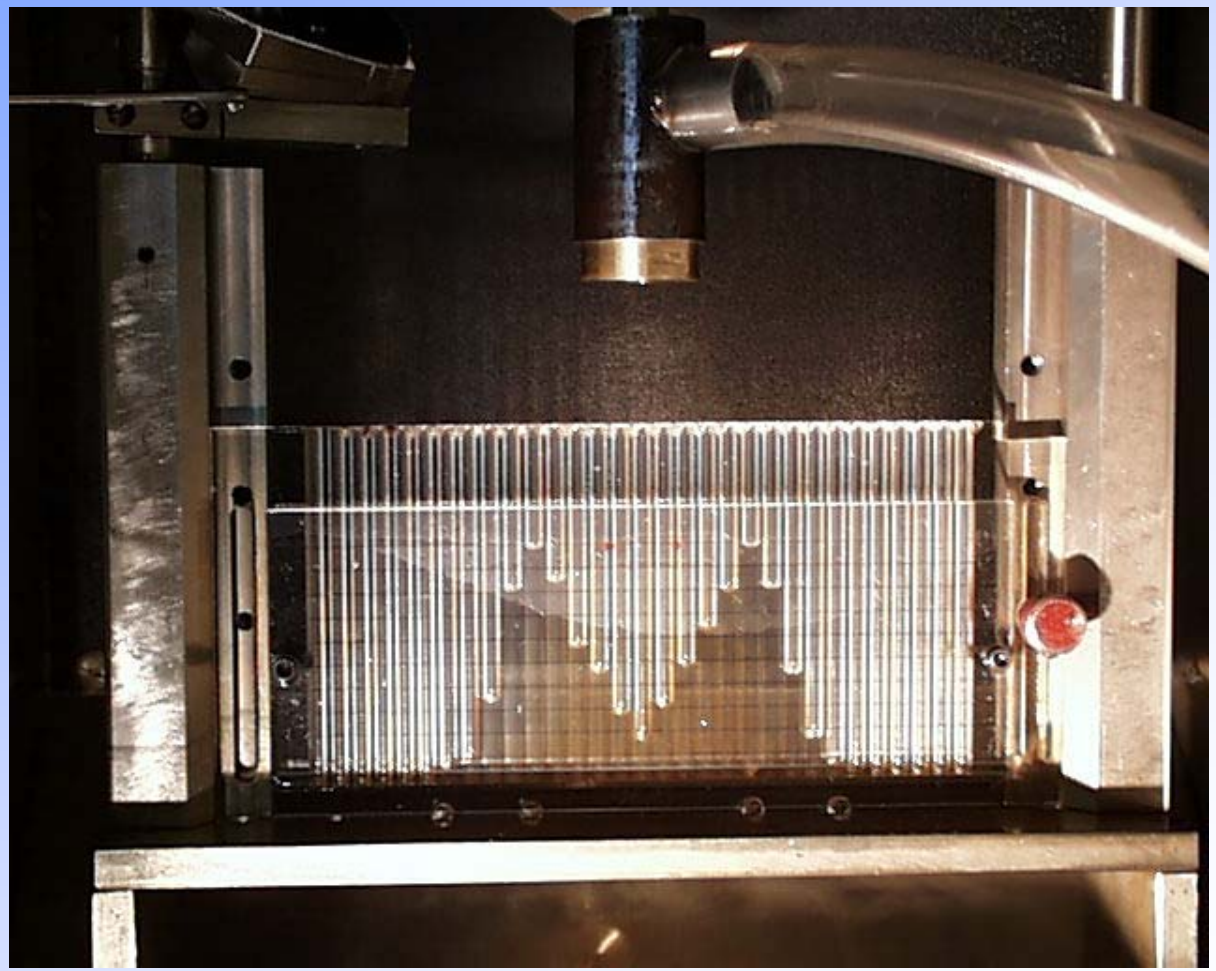
CFD (Fluent) modeling

Fully equipped combustion lab

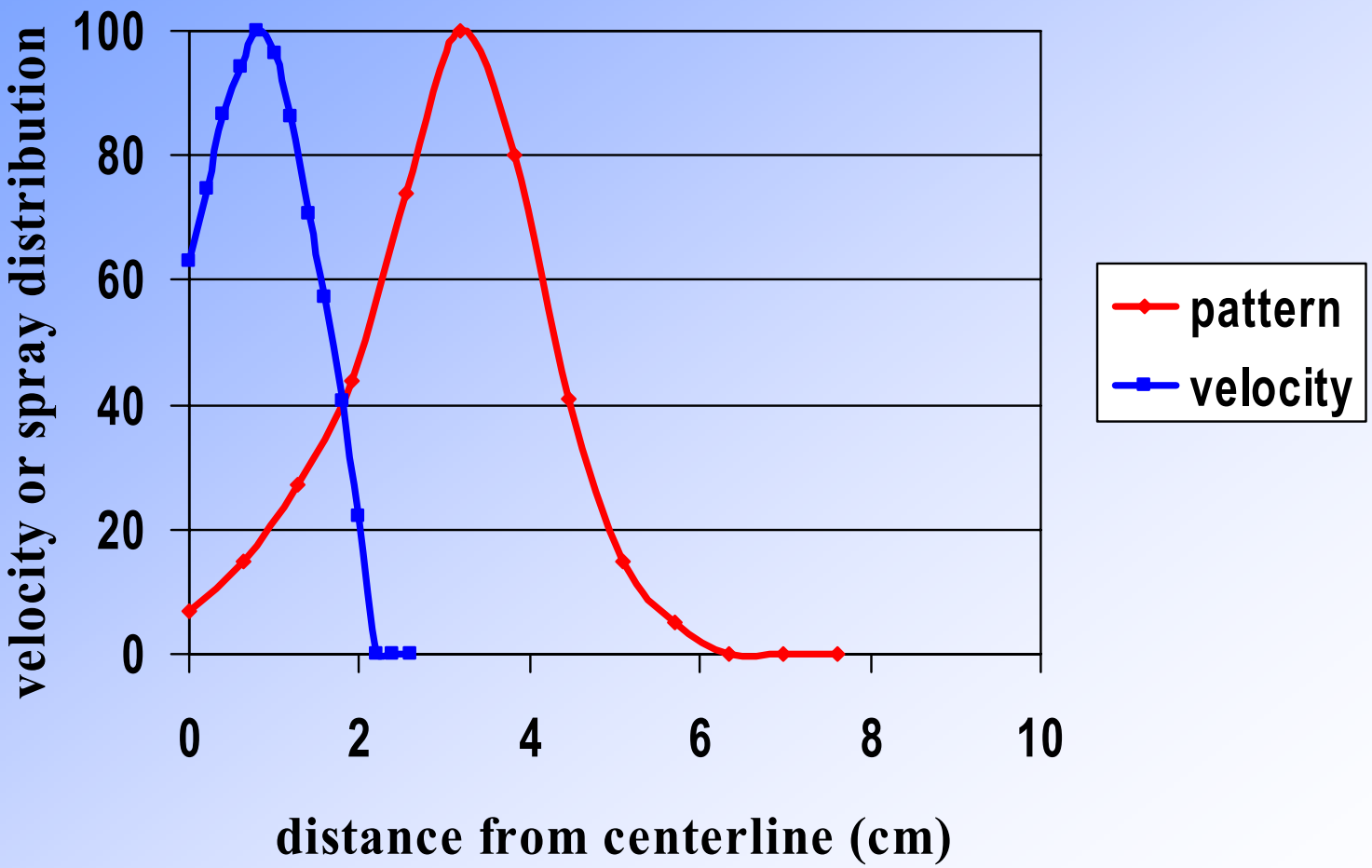
Industry prototyping



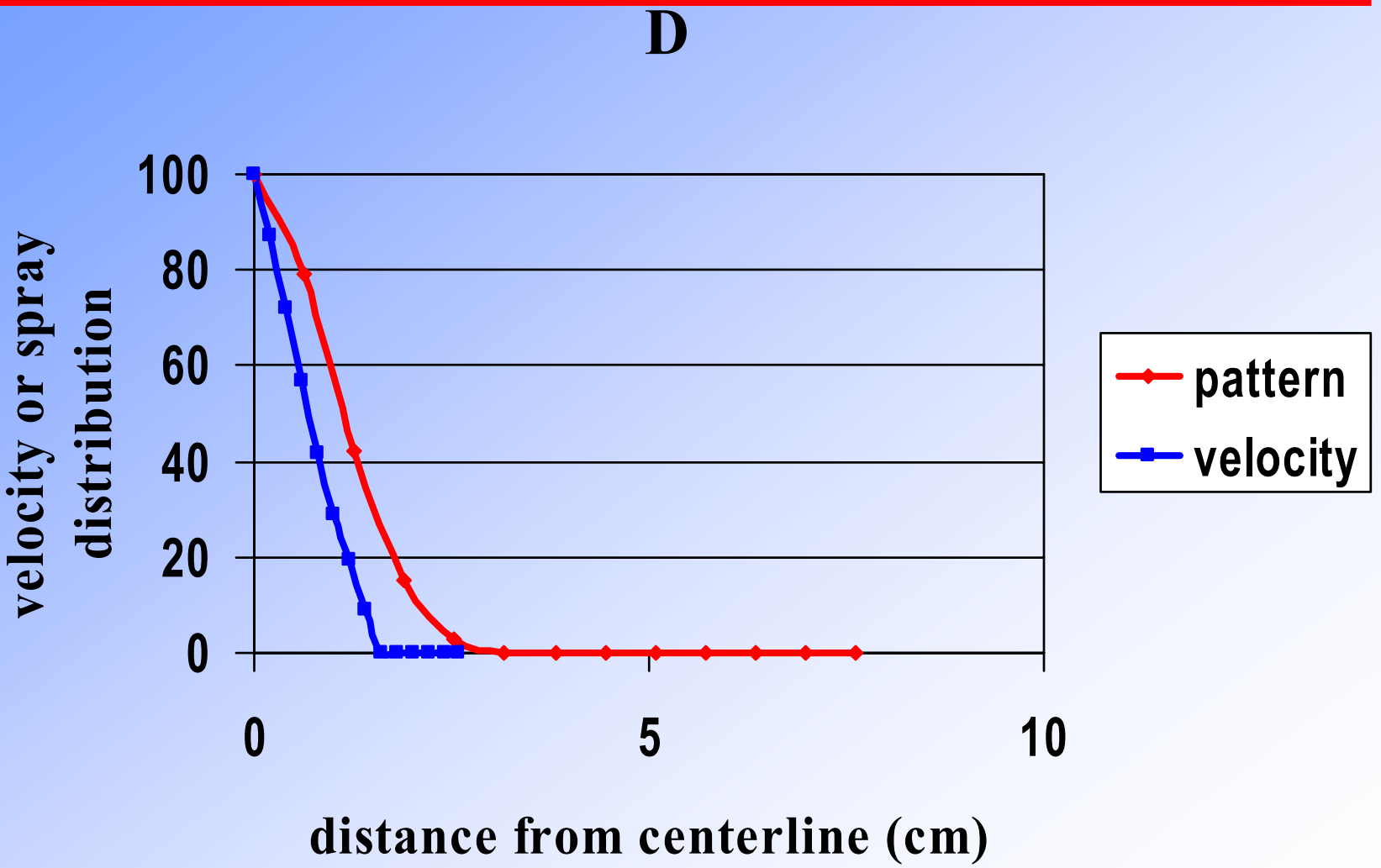
Spray pattern measurement



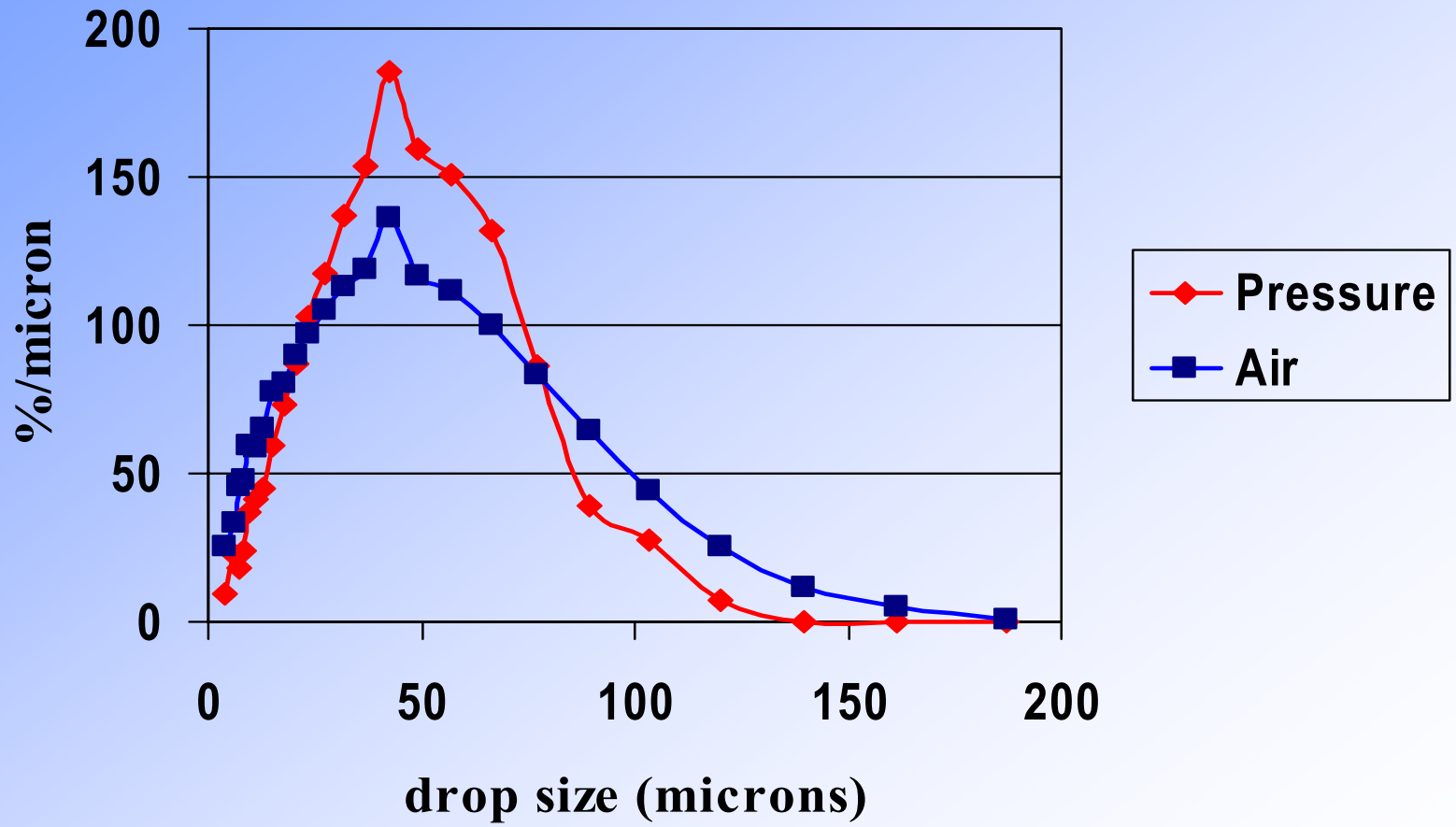
Example coswirl



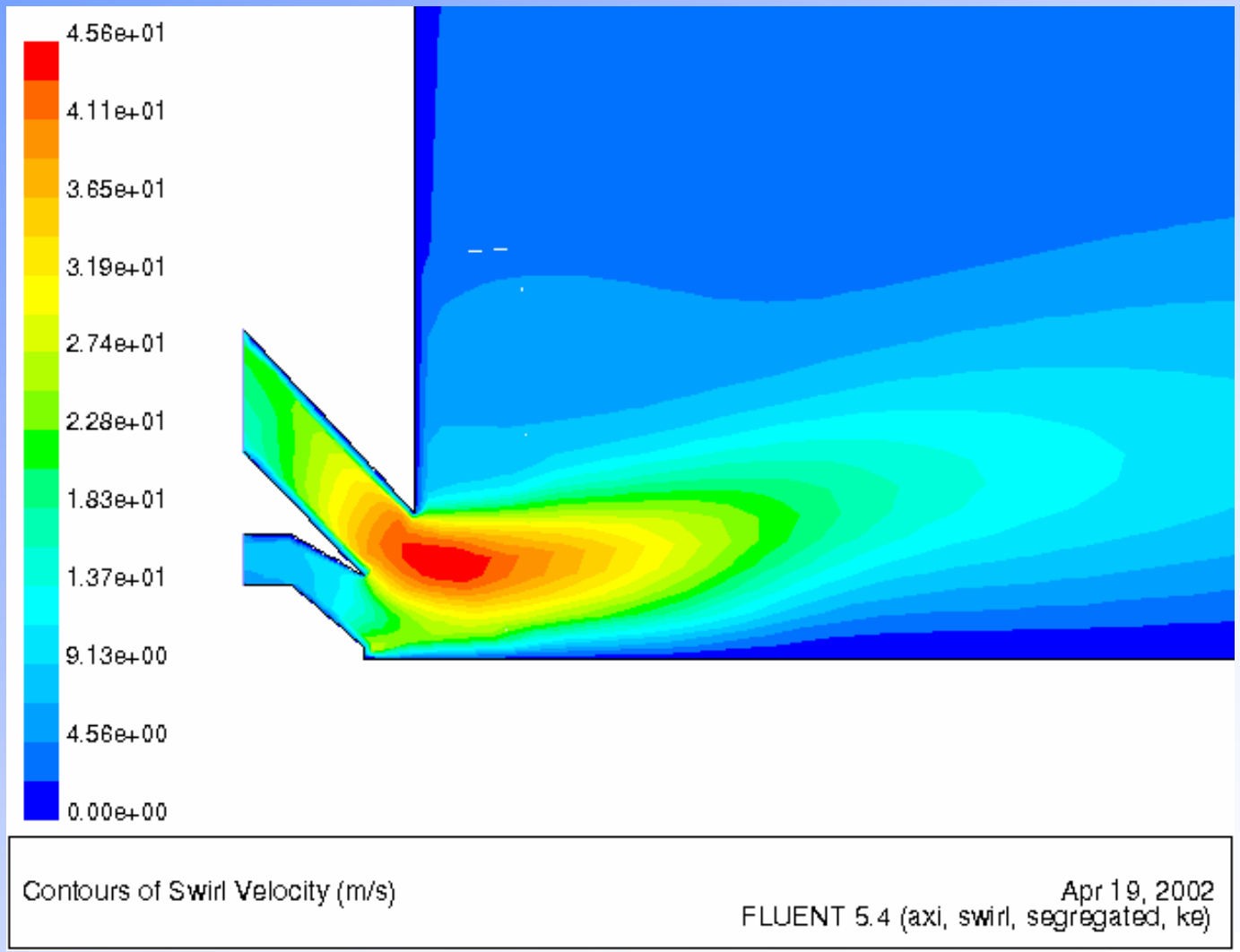
Example counter swirl



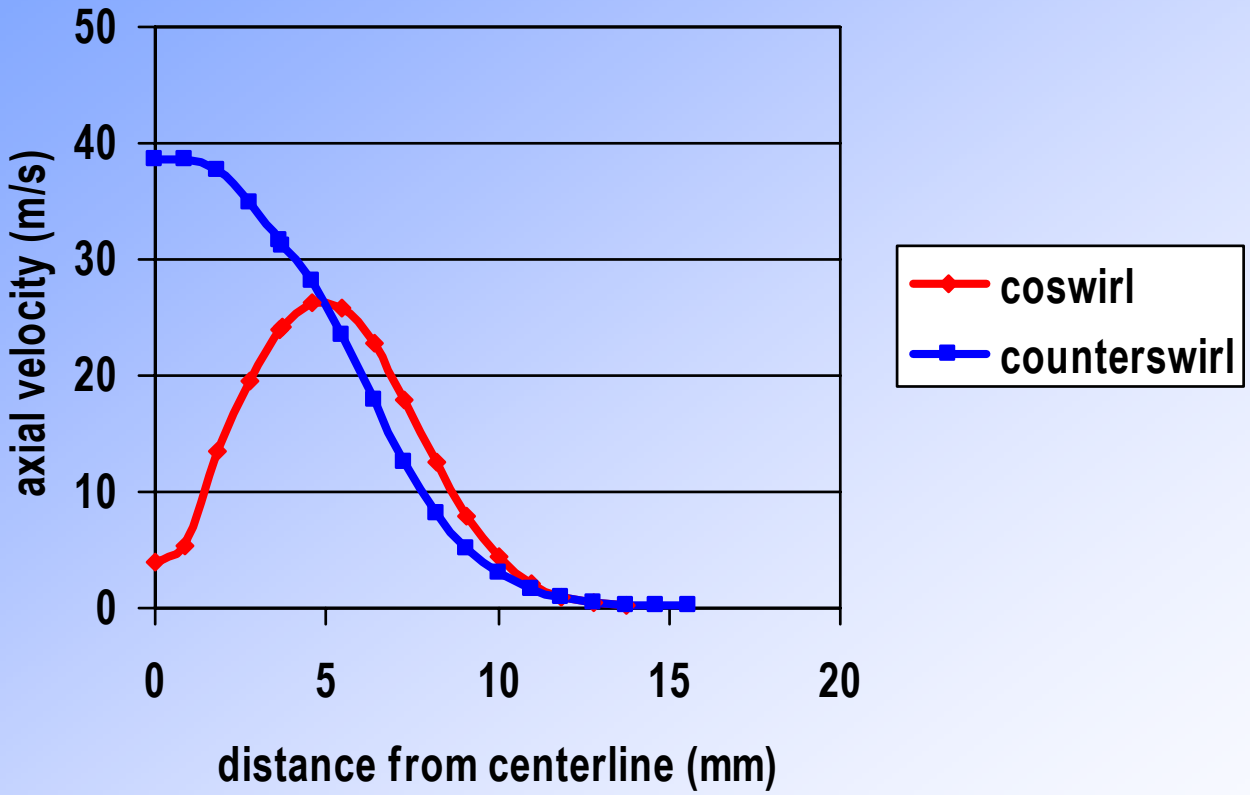
Example drop size measurement



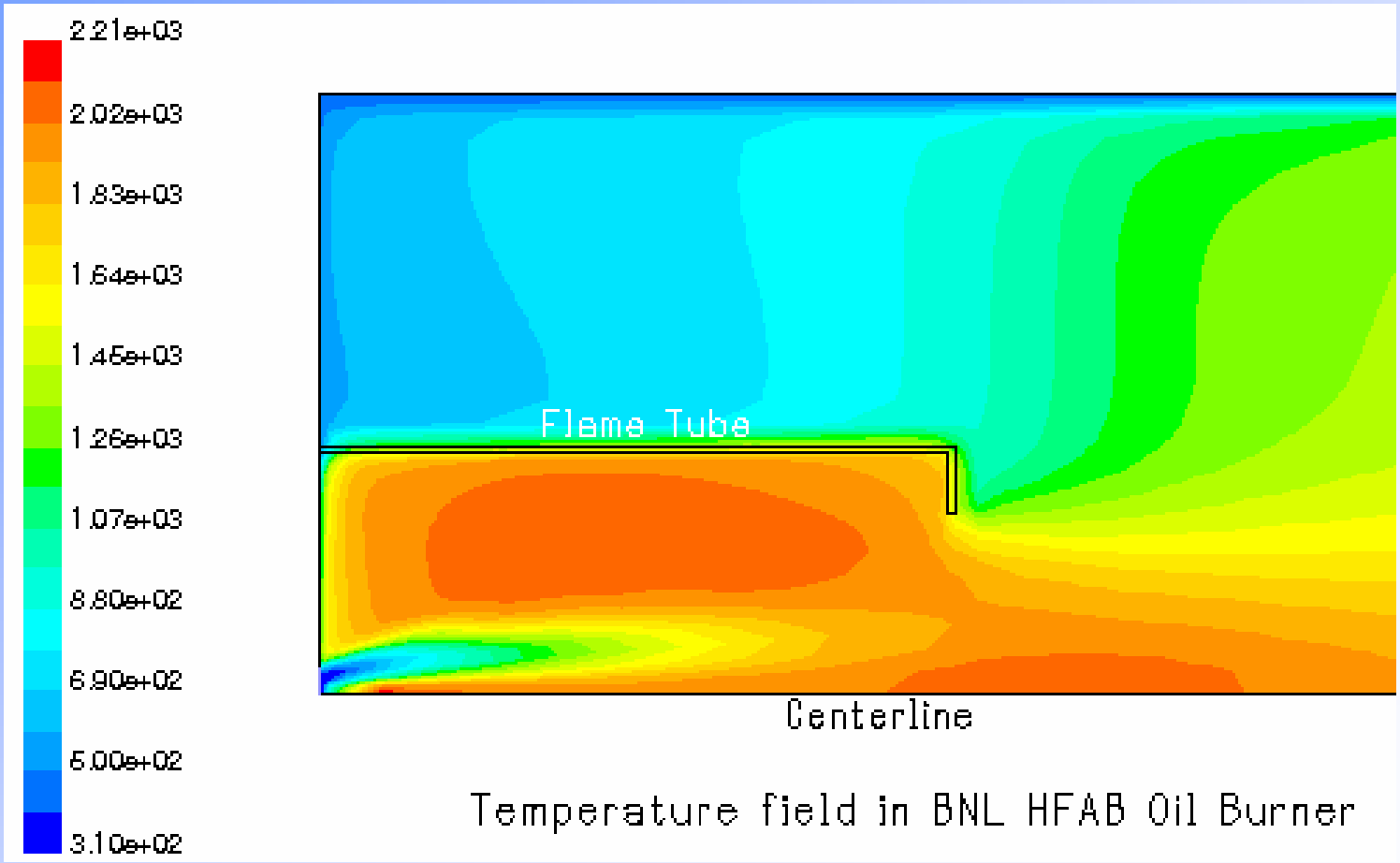
Example CFD results - inside nozzle



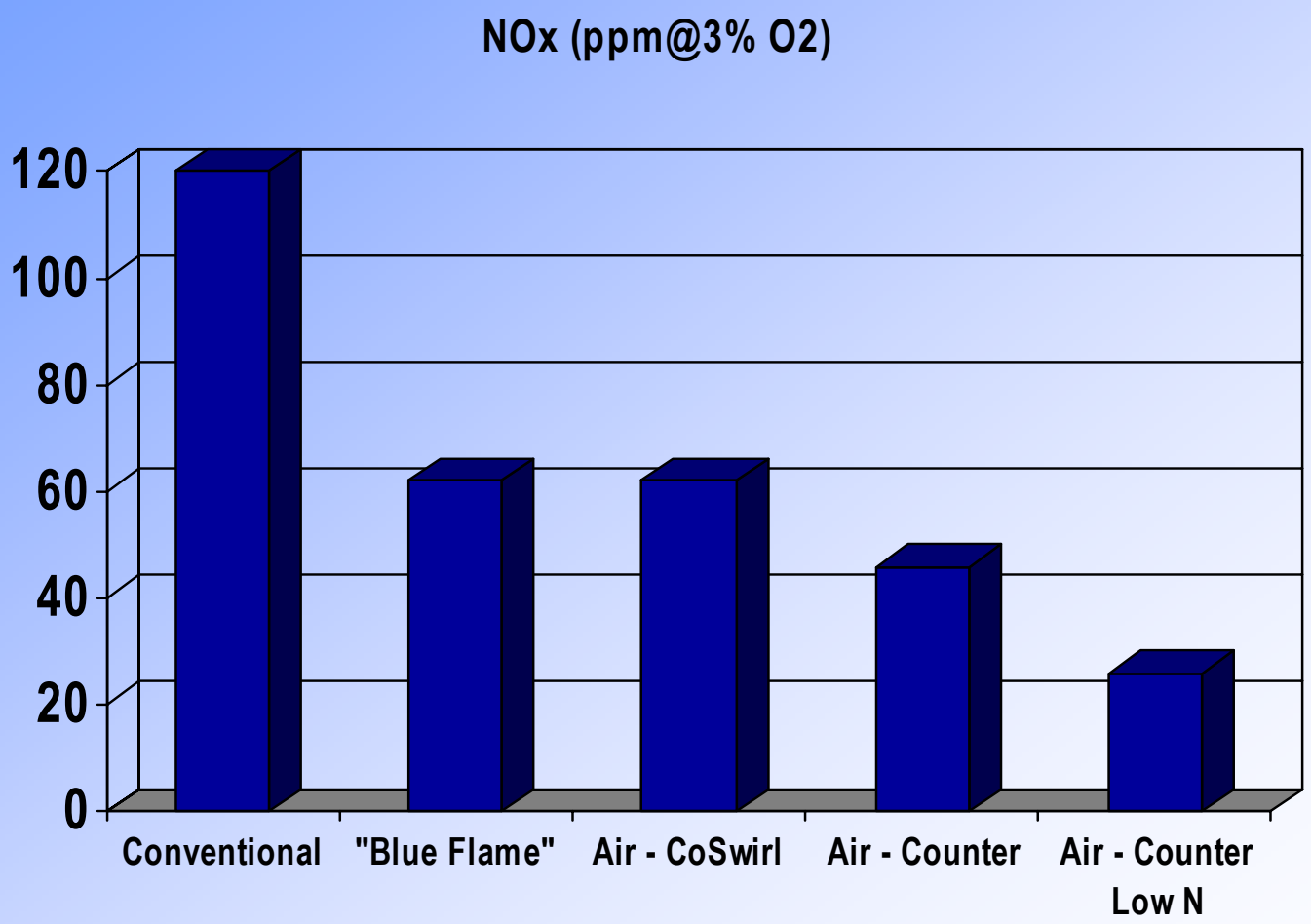
Example CFD results - swirl effect



Example CFD results - flame (K)

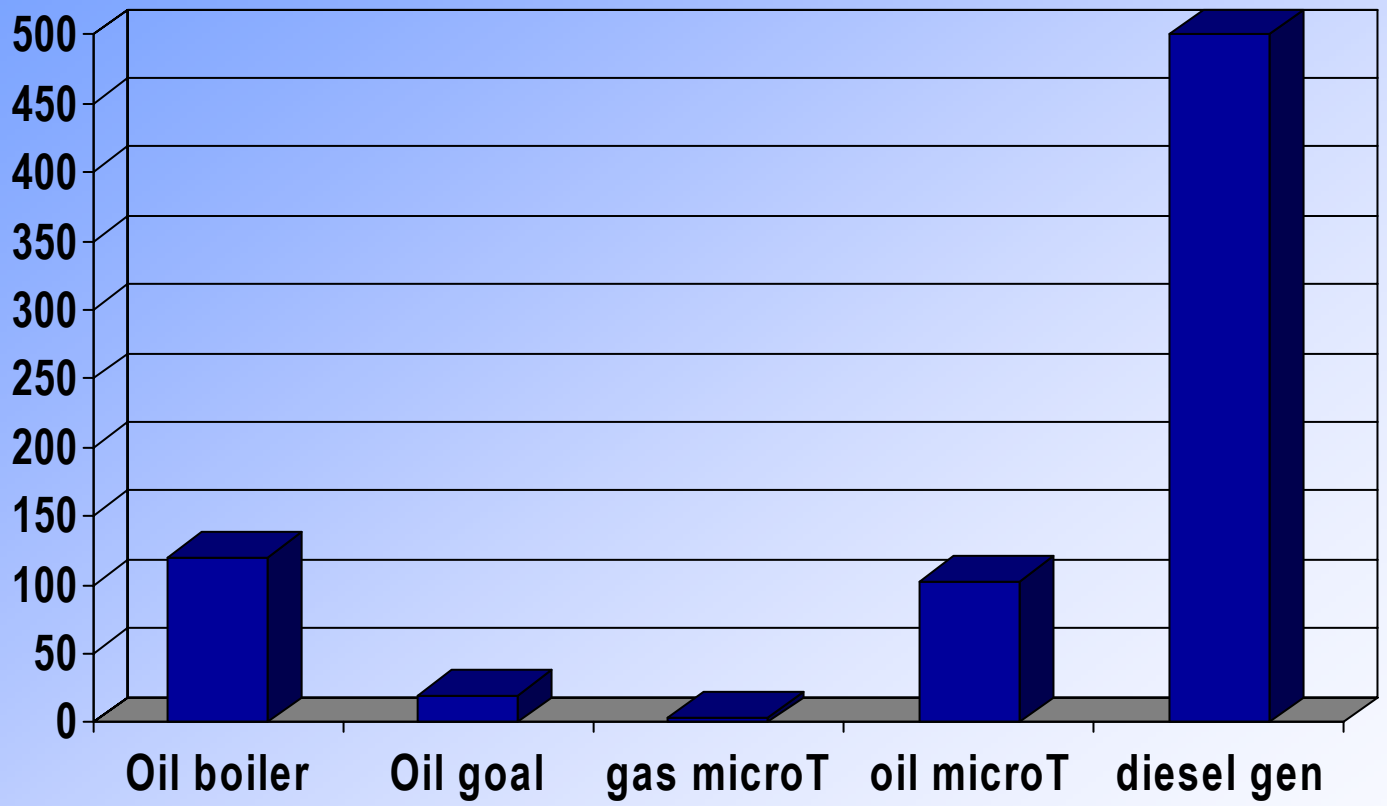


Comparison of NOx Emissions



Microturbine Studies

Microturbine NOx Emissions



Partnerships

The air atomized burner is under active commercialization by Heat Wise (see next presentation)

Several companies in U.S. and Europe are seriously looking at (testing).

Gas-fired microturbine installed in cooperation with Keyspan.

Informal cooperation with numerous companies.

Key Technical Barriers

- Limited U.S. experience with low NOx burners
- Half of U.S. residential appliances are furnaces
- Lack of integration in equipment
- Design tools
- Availability of low N fuel
- A change in service training and tools is required.
- Cost

Risks

- Developed systems will be too expensive and too difficult to service.
- Products rushed to market, without adequate testing and training, will pose CO problem

Future Plans

1. Tests with oil-fired absorption chiller
2. Vaporization / premix studies to add to foundation
3. RFP to engage development teams leading to commercialization of ultra low NOx technologies for a wide range of applications
4. Commercial cooperation on BNL low pressure air atomizing nozzle
5. Extension to larger equipment for commercial / industrial applications
6. NOx reduction with microturbines and IC engines